Nelumbo *Vol 58, (152-156) 2016*
DOI : 10.20324/nelumbo/v58/2016/105915

ISSN (Print) : 0976-5069
ISSN (Online) : 2455-376X

Stigonema tagorum sp. nov. (Stigonemataceae, Cyanoprokaryota) from a stone monument of Santiniketan, West Bengal, India

Nitin Keshari[1], Sudipta Kumar Das[2] and Siba Prasad Adhikary[1,3]✉

[1]Department of Biotechnology, Institute of Science, Visva-Bharati, Santiniketan - 731235, West Bengal, India
[2]Central National Herbarium, Botanical Survey of India, Howrah - 711103, West Bengal, India
[3]Fakir Mohan University, Vyasa Vihar, Balasore – 756020, Odisha, India
✉Corresponding author: sudiptaalgae@gmail.com

भारत के शांतिनिकेतन, पश्चिम बंगाल, शिला स्मारक से *स्टिगोनेमा टैगोरम* जाति. नव (स्टिगोनेमाटासी, साइनोप्रोकैरियोटा)

नितिन केशरी, सुदिप्त कुमार दास एवं शिव प्रसाद अधिकारी

सारांश

साइनोबेक्टरिया/साइनोप्रोकैरियोटिक शैवाल मुख्य रूप से माइक्रोबियल बायो फिल्म के घटक है एवं ये हमारी सांस्कृतिक रूप से महत्वपूर्ण शिला स्मारकों पर भी पाये जाते हैं। इनकी विविधता एवं परिसंरचना को हमेशा अवलोकित किया जाता है क्योंकि ये स्मारकों को अपक्षयित कर नुकसान पहुंचाते हैं। हाल ही में शांति निकेतन, पश्चिमी बंगाल में स्थापित गांधी प्रतिमा से स्टिगोनीमेटासिन जातियों के जैसी *स्टिगोनेमा टैगोरम* नामक शैवाल पाई गई है। टैक्सोन शाखाओं में बंटी एक विशिष्ट प्रकार की है, जो इसे अपने जैसे टैक्सा से अलग करती है ।

ABSTRACT

Cyanobacteria/Cyanoprokaryotes are primary components of the microbial bio-films colonizing on different culturally important stone monuments. Their diversity and eco-physiology was always emphasized as they cause weathering of their substratum leading to disfigurement of the monuments. In the present communication, a novel Stigonematacean species, i.e., *Stigonema tagorum* is described from a stone monument (Gandhi Statue) in Santiniketan, West Bengal. The taxon has a distinguished type of true branching and cellular morphometry which differentiates it from its resembling taxa.

Keywords: *Stigonema tagorum*, Cyanoprokaryote, monuments, Santiniketan

INTRODUCTION

Cyanobacteria/Cyanoprokaryotes are the primary components of the biome colonizing on stone monuments of archaeological and cultural value, causing their disfigurement and weathering (Büdel, 1999; Gaylarde & Morton, 1999; Tomaselli & al., 2000; Videla & al., 2000; Gaylarde & al., 2001; Crispim & al., 2003; Crispim & Gaylarde, 2005). Their biodiversity as well as physiology in Indian monuments were studied time to time (Tripathy & al., 1997, 1999; Roy & al., 1997; Adhikary, 1998; Adhikary & Sahu, 1998; Pattanaik & Adhikary, 2002; Samad and Adhikary, 2008; Sahu & Adhikary, 2012; Keshari & Adhikary, 2014; Adhikary & al., 2015).

Santiniketan (23.68°N; 87.68°E) in Birbhum district of West Bengal is a cultural heritage site and also famous for

Received: 23.06.2016 Accepted: 19.07.2016 Date of Publication: 30.12.2016

Visva Bharati University, founded by the Nobel laureate Rabindranath Tagore. There are several stone and mortar made sculptures and statues were scattered in and around the locality. These are almost 80-100 years old and made by famous contemporary sculpturists of the country. Colonization of 23 cyanobacterial species were found on these monuments with a dominance of *Scytonema millei* Bornet ex Bornet & Flahault and *Tolypothrix campylonemoides* Ghose (Keshari & Adhikary, 2013; Kumar & al., 2014).

In the present communication, a new species of branched, heterocystous genus *Stigonema* (Stigonemataceae, Cyanoprokaryota), i.e., *Stigonema tagorum* is described from a stone monument (Gandhi Statue) in Santiniketan, West Bengal. The detail morphology of the taxon is presented along with a comparative analysis of the same of closely look alike taxa.

MATERIALS AND METHODS

The cyanobacterial species was isolated from the Gandhi statue (23°40.506′ N; 87°40.567′ E), which is made of stone and mortar (Fig. 1 A-D). The GPS data of the sampling site as well as the atmospheric temperature and light intensity near the statue were noted on the spot. The relative humidity data was obtained from the meteorological station, Sriniketan, West Bengal. Blackish brown cyanobacterial crusts were collected from the exposed surfaces using non-destructive method employing adhesive tape strips (La Cono & Urzi, 2003). The biofilms were soaked in sterile distilled water and incubated under fluorescent light for up to 72 hours before observing microscopically. For accurate identification and thorough morphological observation, the sample was transferred to liquid BG-11 medium with and without nitrogen (Rippka & al., 1979) and to agar plates (1.2% w/v agar) of the same medium. The cultures were incubated at 25 ± 1°C under continuous fluorescent light at an intensity of 7.5 Wm^{-2}. As the cyanobacteria could not be isolated to uni-algal culture, a portion of the mixed culture along with the crust was preserved in 4% formaldehyde solution. Light microscopy and photomicrography was done using Olympus BX 41 microscope fitted with a Nikon Coolpix 4500 digital camera. The camera lucida drawings were also made for better illustration. Identification and taxonomic studies of the taxa were made following (Desikachary, 1959), (Komárek & Anagnostidis, 1989, 1999) and (Komárek, 2013).

RESULTS AND DISCUSSION

Stigonema tagorum Sudipta K. Das, N. Keshari & S. P. Adhikary **sp. nov.** **(Fig. 2 A–E).**

Thallus hairy, bushy; trichomes thick, non-uniform, slender in young branches, 8–22 µm broad, olive - green to blackish-green, with true, dichotomously branches of short length (Fig. 2 A, C, E), sometimes 2–3 branches arise side by side (Fig. 2 D); pseudo-branches are also present in mature filaments (Fig. 2 B); sheath prominent in mature filaments, thick, non-lamellated, dark green to yellowish-green; cells broadly elliptical to discoid, of irregular breadth in mature filaments, apical cells hemispherical with rounded tip, slightly constricted at the cross walls, cellular content granular with aerotopes of different size, cells 3.5–10.7 µm long, 5.2–19.8 µm broad; heterocyst intercalary (Fig. 2 B-C), mostly present in mature filaments, rarely young branches, elliptical to tropizoid, slightly broader than neighboring cells, 3.0-10.2 µm long, 5.5–20 µm broad.

Holotype: India: West Bengal, Santiniketan, Gandhi statue (*c.* 52 m), 30.12.2011, 65116, VB 2.1

Habitat and Ecology: Subaerophytic, forming blackish brown crusts on the stone/mortar made statue in association with *Tolypothrix campylonemoides* Ghose. The annual range of air temperature of the study site is 11.5–25.8 °C and relative humidity is 63-74 %.

Etymology: This specific epithet of the taxon was named after the Nobel laureate and founder of the University, Rabindranath Tagore.

Stigonema (Family-Stigonemataceae) is a heterocystous, filamentous cyanobacterial genus with true branching and presence of uni to polyseriate trichome as the distinguishing feature. The occurrences of the taxa of this genus from India are mostly subaerophytic with a few records from moist rocks in an aquatic habitat. The genus is represented by 17 taxa reported so far from India including 14 species, 2 varieties and 1 form (Gupta, 2012). The present taxon from Santiniketan, *Stigonema tagorum* has uniseriate cellular pattern in the filament unlike most of the taxa of the genus. It has partial resemblances with *Stigonema hormoides* (Kütz.) Bornet & Flahault and *Stigonema ocellatum* (Dillwyn) Thuret ex Bornet & Flahault. The phenological comparison of both these taxa with the newly described species is presented in Table 1.

S. tagorum has similarity in cellular morphology, branching pattern and heterocyst structure with *S. ocellatum*, but taxon can be distinguished from the later in

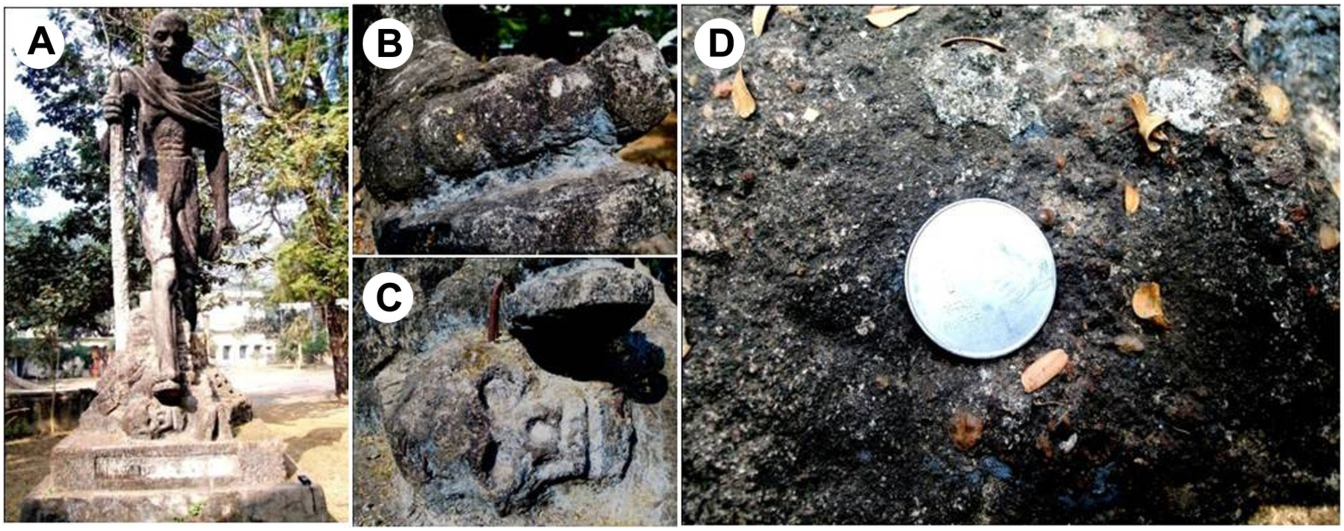

Fig -1: **A-D.** Blackish brown crust of *Stigonema tagorum* sp. nov., colonizing on Gandhi statue in Santiniketan, India.

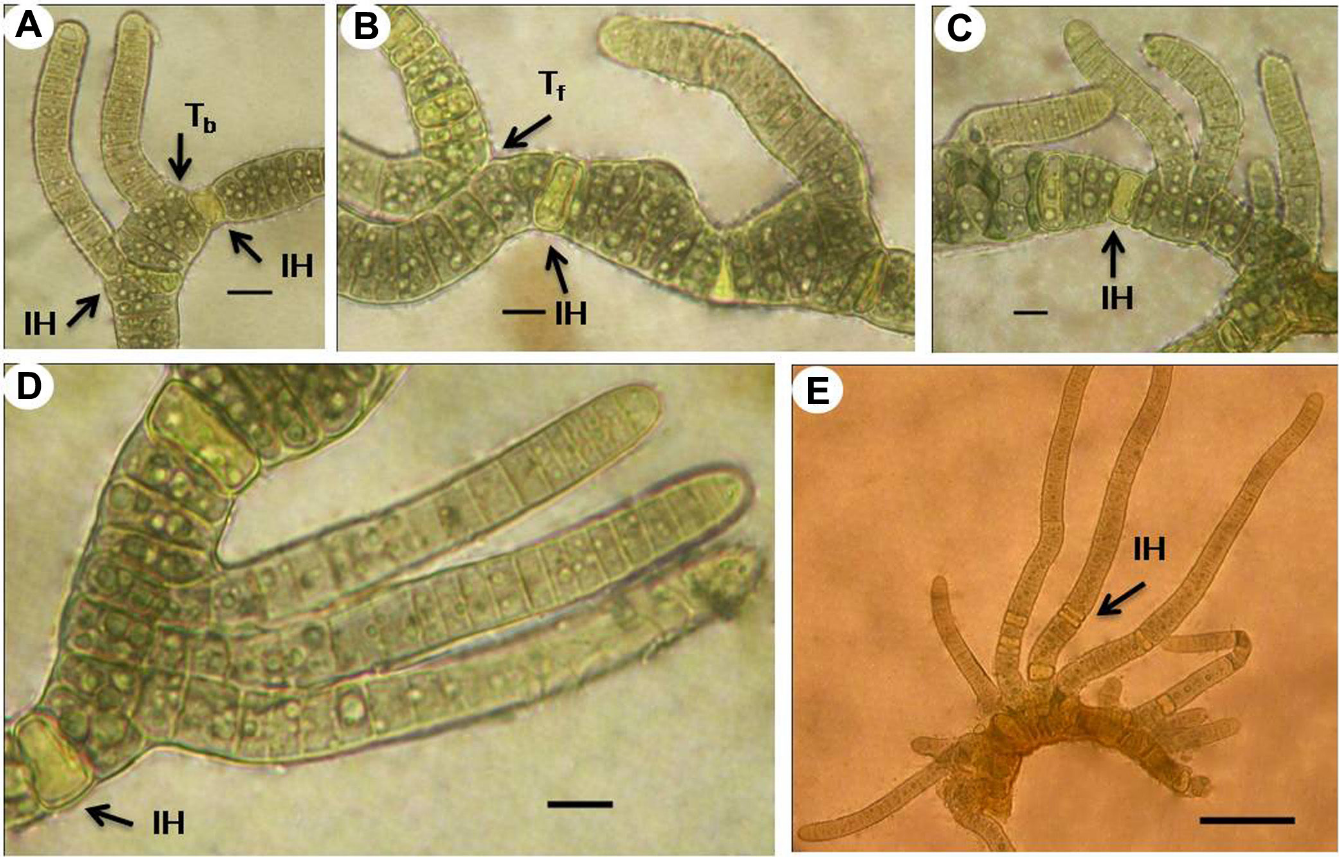

Fig -2: *Stigonema tagorum* sp. nov. showing different morphological features; **A.** T_b – true branching, **B.** T_f – false branching, **C-E.** IH – Intercalary heterocyst. (Scale bar – 20 µm).

Table 1: Comparison of *Stigonema tagorum* with its morphological allied taxa.

Morphological features	*Stigonema tagorum* sp. nov.	*Stigonema hormoides*	*Stigonema ocellatum*
Ecology	Subaerophytic	Subaerophytic	Aquatic or Subaerophytic
Thallus	Hairy, bushy		Bushy clusters
Trichome morphology	Uniseriate, olive green to blackish green	Uniseriate, blackish brown	Rarely uniseriate, mostly biseriate, olive green to brownish
Sheath	Thick, non-lamellated, dark green to yellowish green	Thick, colourless to yellowish brown	Wide, slightly lamellated, yellowish brown
Filament width	8 – 22 µm	7 – 15 µm	Up to 15 µm
Cytological features	Cells broadly elliptical to discoid, 3.5 – 10.7 × 5.2 – 19.8 µm	Cells rounded, 4 – 8 × 5.2 – 8.8 µm	Cells quadrate globose or globose, 6 – 24 µm wide
Branching	True, dichotomous, lesser width than main filament	Rarely true branched, of same width as main filament	True, irregular long branches of same width.
Heterocysts	Intercalary, present in mature filaments, slightly broader than neighbor cells	Lateral	Intercalary or lateral, same width as neighbor vegetative cell

having uniseriate cellular arrangement in the trichome, short branch length and absence of lamellation in the sheath. Similarly, the rarity of true branching and lateral positioning of heterocysts are the differentiating features of *S. hormoides* from the novel taxa. The cells in the filaments of *S. tagorum* are wider and with presence large number of aerotopes, gives it a multiseriate appearance. But, its uniseriate filaments confined the taxa to a small but unique cluster of *Stigonema* species. Like other *Stigonema* taxa, true branching is clearly observed in the present species with the uniqueness of continuous true branches and appearances of false branching.

Based on the distinct morphological features observed, the present taxon *Stigonema tagorum* Sudipta K. Das, N. Keshari & S. P. Adhikary can be regarded as a new species and can be treated as a significant addition to Indian cyanobacterial flora.

ACKNOWLEDGEMENT

The authors are grateful to the Department of Science and Technology, Government of India, for financial assistance and to the authorities of Visva Bharati, Santiniketan for providing laboratory facilities.

REFERENCES

ADHIKARY, S. P. 1998. Polysaccharides from mucilaginous envelope layers of cyanobacteria and their ecological significance. *J. Sci. Indus. Res.* 57: 454–66.

ADHIKARY, S. P. AND J. K. SAHU. 1998. UV protecting pigment of the terrestrial cyanobacterium *Tolypothrix byssoidea*. *J. Plant Physiol.* 153: 770–773.

ADHIKARY, S. P., N. KESHARI, C. URZI AND R. DE PHILLIPIS. 2015. Cyanobacteria in biofilms on stone temples of Bhubaneswar, Eastern India. *Algol. Studs.* 147: 67–93.

ANAGNOSTIDIS, K. AND J. KOMÁREK. 1990. Modern approach to the classification system of cyanophytes. 5. Stigonematales. *Arch. Hydrobiol. Suppl. Algol Studs.* 59: 1–73.

BÜDEL, B. 1999. Ecology and diversity of rock inhibiting cyanobacteria in tropical regions. *Eur J Phycol.* 34: 361–370.

CRISPIM, C. A. AND C. C. GAYLARDE. 2005. Cyanobacteria and biodeterioration of cultural heritage: A review. *Microb. Ecol.* 49: 1–9.

CRISPIM, C. A., P. M. GAYLARDE AND C. C. GAYLARDE. 2003. Algal and cyanobacterial biofilms on calcareous historic buildings. *Curr. Microbiol.* 46: 79–82.

DESIKACHARY T. V. 1959. *Cyanophyta*. Indian Council of Agricultural Research, New Delhi, pp. 686.

GAYLARDE, C. C. AND L. H. G. MORTON. 1999. Deteriogenic biofilms on buildings and their control: A review. *Biofouling* 14: 59–74.

GAYLARDE, P. M., C. C. GAYLARDE, P. S. GUIAMET, S. G. GOMEZ DE SARAVIA AND H. A. VIDELA. 2001. Biodeterioration of Mayan buildings at Uxamal and Tulam, Mexico. *Biofouling* 17: 41–45.

GUPTA, P. 2012. *Algae of India. A checklist of Cyanoprokaryota (Cyanophyceae)*, Botanical Survey of India, Kolkata, *Vol. 1*. pp. 160.

KESHRI, N. AND S. P. ADHIKARY. 2013. Characterization of cyanobacteria isolated from biofilms on stone monuments at Santiniketan, India. *Biofouling* 29: 525–36.

KESHARI, N. AND S. P. ADHIKARY. 2014. Diversity of cyanobacteria on stone monuments and building facades of India and their phylogenetic analysis. *Int. Biodeter. Biodegr.* 90: 45–51.

KOMÁREK, J. 2013. *Cyanoprokaryota. Part 3: Heterocystous genera*. In: Büdel, B., G. Gärtner, L. Krienitz and M. Schagerl (Eds.), Freshwater flora of Central Europe. Springer Spektrum, Heidelburg. pp. 1130.

KOMÁREK, J. AND K. ANAGNOSTIDIS. 1989. Modern approach to the classification system of cyanophytes 4. Nostocales *Arch. Hydrobiol. Suppl. Algol. Studs.* 56: 247–345.

KUMAR, D., N. KESHARI, S. K. DAS, S. BHAKTA AND S. P. ADHIKARY. 2014. Algal diversity in different habitats of Santiniketan, West Bengal. *J. Bot. Soc. Bengal* 68(1): 47–57.

LA CONO, V. AND C. URZI. 2003. Fluorescent in situ hybridization on samples taken with adhesive tape strips. *J. Microbiol. Methods* 55: 65–71.

PATTANAIK, B. AND S. P. ADHIKARY. 2002. Blue green algal flora of some archaeological sites and monuments of India. *Feddes Repertor.* 113: 289–300.

RIPPKA, R., J. DERUELLES, J. B. WATERBURY, M. HERDMAN AND R. Y. STANIER. 1979. Genetic assignments, strain histories and properties of pure cultures of cyanobacteria. *J. Gen Microbio.* 111: 1–61.

ROY A., P. TRIPATHY AND S. P. ADHIKARY. 1997. Epilithic blue green algae/cyanobacteria from tamples of India and Nepal. *Arch. Hydrobiol. Suppl. Algol. Studs.* 86: 147–161.

SAHU, J. K. AND S. P. ADHIKARY. 2012. Phylogenetic analysis of two stigonematalean cyanobacteria based on 16s rRNA sequence. *Phykos* 42: 59–64.

SAMAD, L. K. AND S. P. ADHIKARY. 2008. Diversity of micro-algae and cyanobacteria on the building facades and monuments in India. *Algae* 23: 91–114.

TOMASELLI, L., G. LAMENTI, M. BOSCO AND P. TIANO. 2000. Biodiversity of photosynthetic microorganisms dwelling on stone monuments. *Int. Biodeter. Biodegr.* 46: 251–258.

TRIPATHY, P., A. ROY AND S. P. ADHIKARY. 1997. Survey of epilithic blue green algae (cyanobacteria) from temples of India and Nepal. *Arch. Hydrbiol. Suppl. Algol. Stud.* 87: 43–57.

TRIPATHY, P., A. ROY, N. ANAND AND S. P. ADHIKARY. 1999. Blue-green algae flora of rock surface of temples and monuments of India. *Feddes Repertor.* 110: 133–144.

VIDELA, H. A., P. S. GUIAMET AND S. G. GOMEZ DE SARAVIA. 2000. Biodeterioration of Mayan archaeological sites in the Yukatan Peninsula, Mexico. *Int. Biodeter. Biodegr.* 46: 335–341.